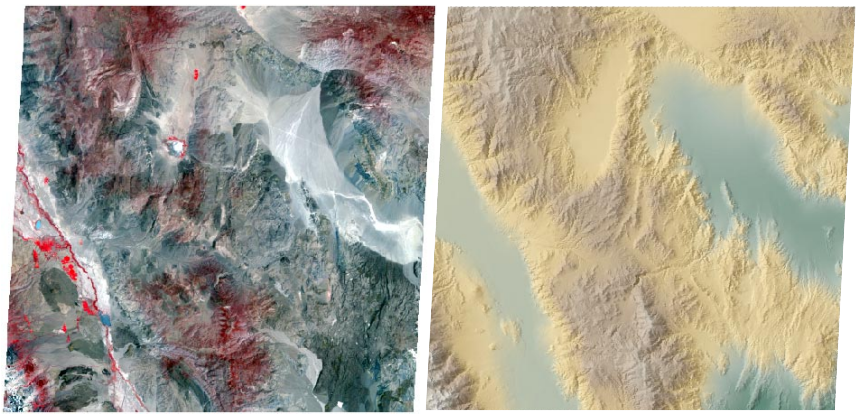
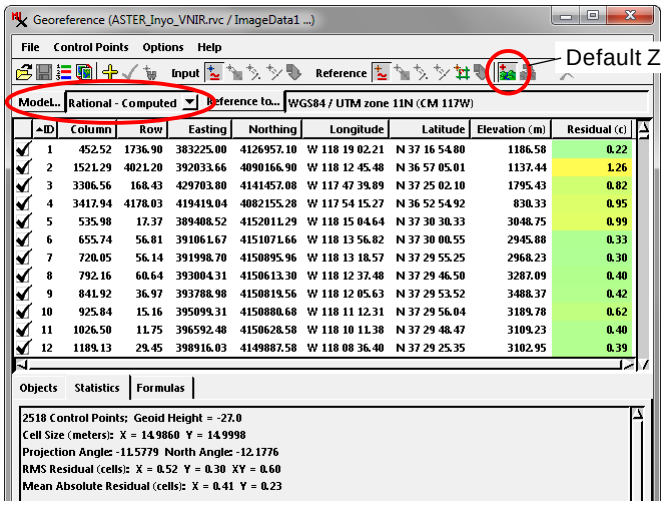
Compute Rational Polynomial Model for Orthorectification

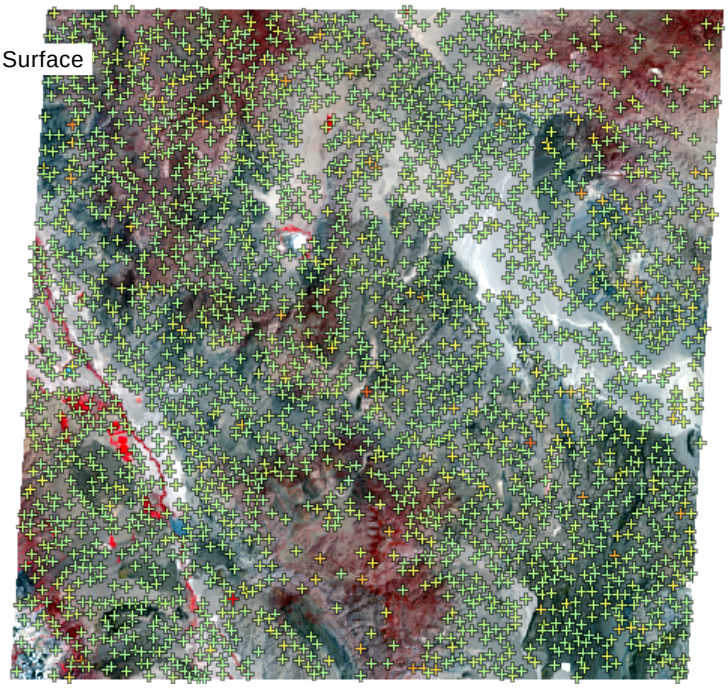
A rational polynomial orthorectification model is an empirical coordinate transformation that relates row and column coordinates in an unrectified image to latitude, longitude, and terrain elevation. The Georeference process in TNTmips can use 3D control points to compute a rational polynomial model for an image (or it can incorporate rational polynomial coefficients supplied with the image). This rational polynomial model can then be used in the Resample process to orthorectify the image bands.

To compute a rational polynomial model, choose *Rational - Computed* from the Model menu (use *Rational - Predefined* if you already have rational polynomial coefficients supplied by the image vendor). You are prompted to select an elevation raster covering the image area and to specify the geoid height for the area (see the tutorial entitled *Orthorectification Using Rational Polynomials* for details on geoid height).



ASTER scene (left) and color shaded-relief image (right) covering an area in eastern California and western Nevada, USA. The scene is about 64 km wide and spans several mountain ranges and intervening deep desert valleys. Ground elevations range from 637 to 4083 meters, resulting in very significant local distortions in the ASTER image due to relief displacement. The ASTER scene is illustrated here using visible and near-infrared bands with 15-meter cell size.





ASTER 15-meter image bands georeferenced with 2518 3D control points generated by the Auto-Register operation using a reference orthoimage tileset and reference 10-meter National Elevation Dataset elevation raster. The rational polynomial coordinate transformation formula computed from these control points (shown on the Formulas panel and reproduced below) results in Mean Absolute Residual values of X = 0.41 and Y = 0.23 cells. Orthorectification results for this image using the derived formula are shown on the next page.

$x = 2.32341883(lon + 117.99141791)\quad y = 3.05544771(lat - 37.1811398)\quad z = 0.0007041(elev - 2071.73237751)$

$rowNum = 0.00235261 - 0.23102181(x) - 1.13163261(y) - 8.9298161E\text{-}005(z) + 0.00111677(xy) - 0.00263212(x^2)$

$rowDen = 1$

$row = 2100(rowNum / rowDen) + 2100$

$colNum = 0.00412646 + 1.00767178(x) - 0.18603843(y) + 0.00625916(z) - 0.00451425(xy)$

$colDen = 1 + 0.00057417(x) - 0.00205997(z) + 0.00085671(xyz) + 0.00053265(xz^2)$

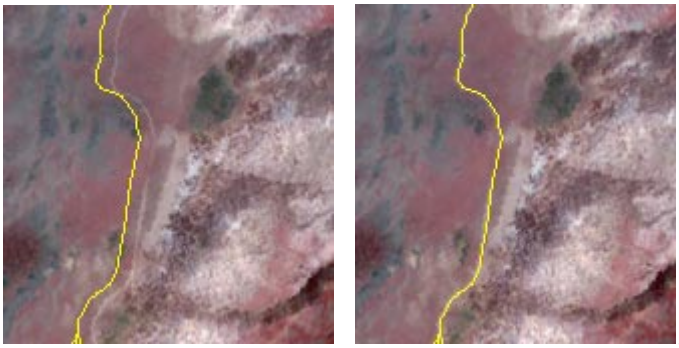
$col = 2490(colNum / colDen) + 2490$

The Rational - Computed option determines the formula for the rational polynomial transformation from 3D control points. You can place 3D control points manually using a reference image and the selected DEM using the option to *Default Z from Surface*; at least 50 well-chosen 3D control points are typically needed for accurate results. You can also use the Auto-Register procedure to automatically generate a large number of control points using a reference image (see the Technical Guide entitled *Georeference: Auto-Register to Reference Image*). Elevation values are automatically assigned for the auto-generated points when the *Default Z from Surface* option is active.

The computed rational polynomial model is used to compute the residual values shown in the control point list. The formulas for the transformation are shown on the Formulas tabbed panel.

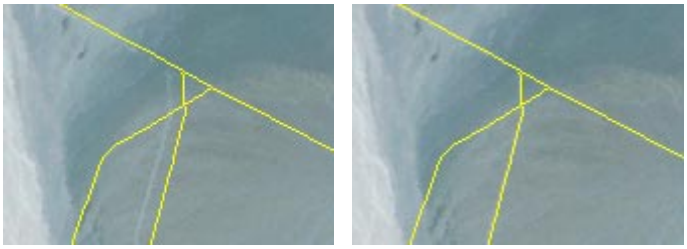
(over)

Raw **RPC Orthorectified**



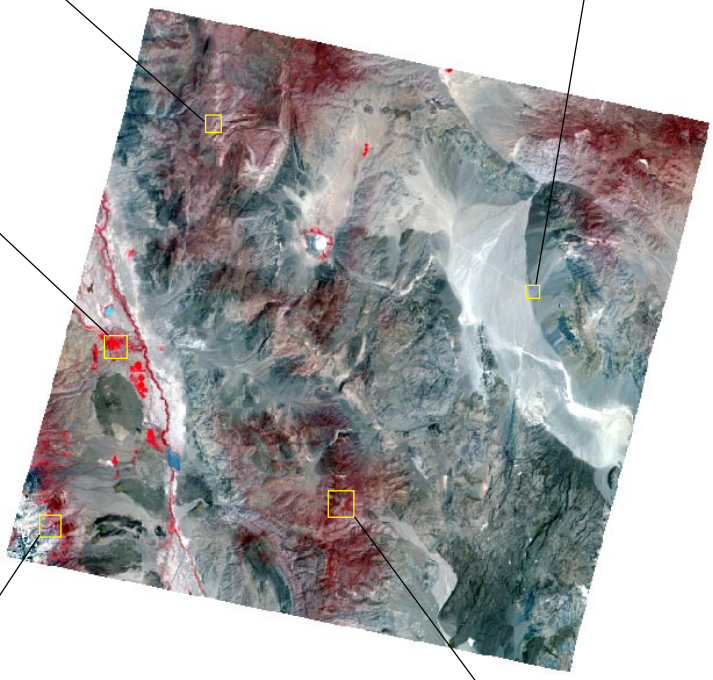
Road, elevation 3130 m. Road offset of ~110 m corrected in orthorectified image.

Raw **RPC Orthorectified**

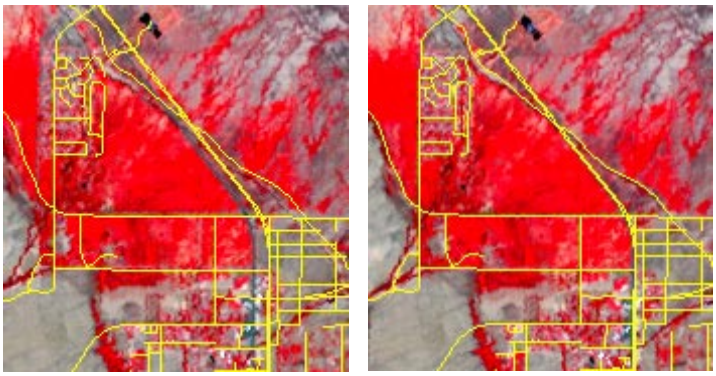


Road intersection, elevation 1003 m. Road offset of ~95 m corrected in orthorectified image.

ASTER image orthorectified using RPC model computed in TNTmips Georeference process from 3D control points.

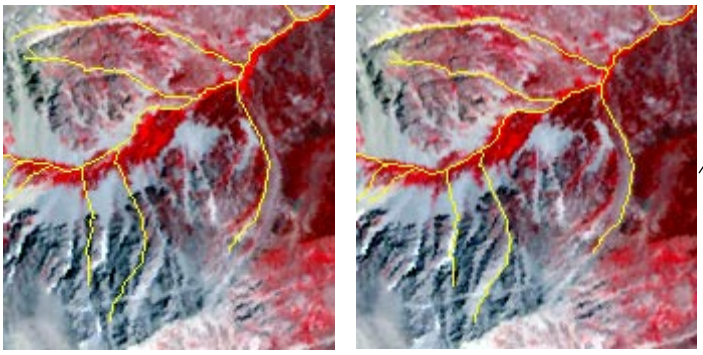


Raw **RPC Orthorectified**

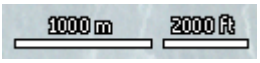


Roads and highway, elevation 1215 m. Road offsets of ~105 m corrected in orthorectified image.

Raw **RPC Orthorectified**

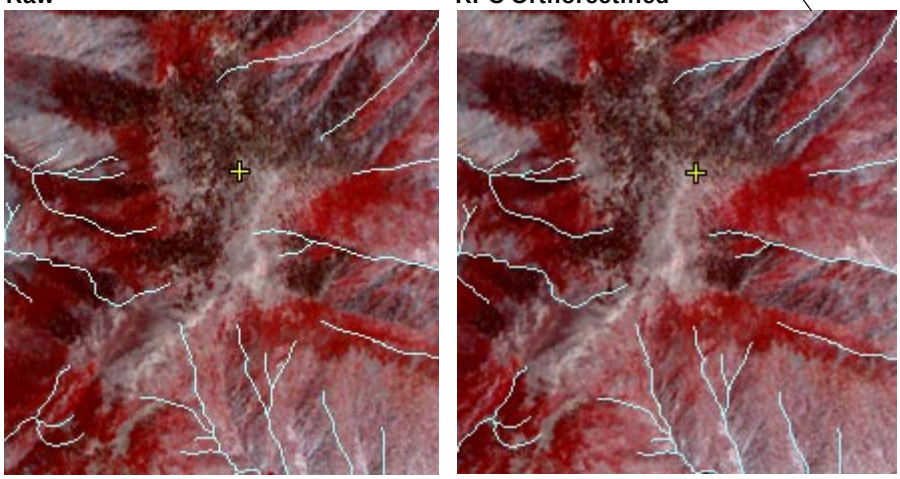


Streams, elevation 2200 to 3400 m. Stream offsets of up to 133 m corrected in orthorectified image.



Scales for all detail images.

Raw **RPC Orthorectified**



Streams and mountain peak (cross), peak elevation 3380 m. Stream and summit offsets up to 283 m corrected in orthorectified image.

Evaluation of RPC orthorectification results for ASTER scene

The detail images on this page show the raw and RPC-orthorectified ASTER image with overlays of geometric reference data (2012 TIGER roads and National Hydrography Dataset stream flow lines). All detail images are presented at the same scale (note scale bars above). Distortions in the raw image due to local elevation variations result in mismatches between the reference geometric data and the location of corresponding features in the image. The RPC orthorectification has corrected these local image distortions and provides a much better match between image features and map features.